



Report of the Missouri Mathematics Pathways Task Force on Building Math Pathways into Programs of Study

submitted to
Complete College America and
The Charles A. Dana Center at the University of Texas-Austin

June 2015



Our commitment to increase educational attainment

In August 2010, Governor Jay Nixon challenged institutions to increase the percentage of Missourians aged 25 to 64 holding a high-quality postsecondary credential to 60 percent by 2025. This objective is similar to one issued by President Obama, and identical to one endorsed by several philanthropic organizations. The Coordinating Board for Higher Education has aggressively pursued what has become known as "The Big Goal."

As the global information economy continues to grow, the need to increase educational attainment has taken on greater urgency. There is little disagreement that higher education is essential to Missouri's economic, social, and cultural vitality. The state's ability to compete in the twenty-first century economy is wholly dependent on creating a highly-skilled and well-educated workforce.

We not only need more college graduates, we need more of them in specific disciplines, especially the STEM fields. In 2010, the National Research Council declared that the United States' competitiveness in the global marketplace requires a highly qualified workforce, which "demands that virtually all job-seekers be at least . . . 'proficient' in mathematics and general science and that the nation have a cadre of highly creative individuals who possess an extraordinary capacity for mathematics, science and engineering."

One reason for the low production of STEM graduates is that mathematics—the lingua franca of STEM disciplines—is a major obstacle for many college students. In Missouri, well over half of all entering college freshmen require remediation in mathematics, and even non-remedial students struggle in college-level mathematics courses. Moreover, few students take a mathematics course beyond the minimum required for graduation. We have too many students ill-prepared to succeed in mathematics and too few interested in pursuing further study in mathematics-based fields.

This is indeed unfortunate because the importance of mathematical skills and reasoning to societal progress is greater than ever. The study of mathematics provides students with logical reasoning and analytical and problem solving skills. Mathematics also imbues in graduates the kind of thinking and habits of mind crucial for addressing the challenges of the modern world.

Too often we hear the refrains "I'm just not good in math" and "I don't need math for my career." Part of our challenge is changing perceptions of mathematics from something to be feared to something essential to one's success in college and career. To that end, we must focus our attention not only on what is taught but how it is taught. We must align the appropriate mathematical concepts and skills with each program of study and do a better job of teaching those concepts and skills.

In that context, I am pleased to share with you the Report of the Missouri Mathematics Pathways Task Force (MMPT). MDHE directed the formation of the MMPT last fall and charged it to explore options and make recommendations that will significantly increase the percentage of students completing degree programs and student success rates in mathematics gateway courses without compromising the integrity of mathematics instruction. The department asked the task force to consider the effectiveness of college algebra and other entry-level college courses and to evaluate how seamlessly existing mathematics courses transfer between institutions.

The MMPT is committed to implementing the recommendations included in this report. Over the next year, the task force will:

- Develop strategies to familiarize departments, instructors and advisors with alternative approaches to entry-level courses, inclusive of content, instruction and delivery mechanisms;
- Communicate its recommendations to relevant professional associations, state decision-makers, university and college leaders and other relevant stakeholders;
- Collect and analyze data to measure effectiveness of existing and new entry-level mathematics courses, including dual enrollment courses taught in the high schools; and
- Explore ways to improve alignment with secondary-level mathematics curriculum.

The members of the Coordinating Board and I wish to express our appreciation to the members of the Missouri Mathematics Pathways Task Force for their fine work on this report. We look forward to continuing this dialogue with the objective of resolving one of the most persistent inhibitors to student success in higher education today.

Regards,



David R. Russell
Commissioner of Higher Education

Executive Summary

Signed into law in 2012, HB 1042 requires all public institutions in Missouri to “to replicate best practices in remedial education.” One best practice identified by the Missouri Department of Higher Education (MDHE) and the Task Force on College and Career Readiness (TCCR) is the alignment of gateway courses—particularly those in mathematics—with academic programs of study.

As the MDHE and the TCCR were implementing the provisions of HB 1042, Missouri was selected to participate in “Building Math Pathways into Programs of Study,” sponsored by Complete College America in collaboration with the Charles A. Dana Center at the University of Texas-Austin. The goal of the “Pathways” initiative is to “increase the percentage of students who pass gateway math courses and enter programs of study in one academic year by building math pathways.”

The MDHE formed the Missouri Mathematics Pathways Task Force (MMPT) to guide the state’s work on this project. The MDHE charged the MMPT with exploring options and making recommendations that would, one, increase significantly students’ success rates in mathematics gateway courses without compromising the integrity of the mathematics; and two, increase significantly the percentage of students completing degree programs. The MMPT has thus far met seven times since October 2014 in pursuit of the project’s objectives and has compiled in this report a summary of its work over the past eight months. In brief, the MMPT recommends the following:

- ▶ Recommendation 1.1: Revise the CBHE policy regarding prerequisite courses for entry-level general education mathematics courses so that the prerequisite course for each college-level course is appropriate.
- ▶ Recommendation 1.2: Establish statewide articulation agreements (while respecting the autonomy of each institution) for the alternative pathway mathematics courses that meet the general education mathematics requirements and their prerequisite courses.

- ▶ Recommendation 2.1: Institutions should align the process of placing students in credit-bearing courses with alternative pathway courses.
- ▶ Recommendation 2.2: The K-12 and higher education sectors should collaborate to align high school mathematics courses with entry college-level mathematics courses.
- ▶ Recommendation 2.3: Create college-level mathematics courses that serve as alternatives to the College Algebra course and that are aligned to targeted programs of study.
- ▶ Recommendation 2.4: Identify prerequisites for alternative college-level mathematics courses that are aligned to targeted programs of study.
- ▶ Recommendation 3.1: Hold a second Mathematics Summit to disseminate information and policy recommendations regarding the work of the MMPT.
- ▶ Recommendation 3.2: Develop a process for the collection and analysis of data regarding the success of alternative courses.

As the project moves into its second year, the MMPT is set to begin implementing project objectives. The MMPT is also planning Missouri’s second mathematics summit to be held this September in Columbia. This summit will be geared towards generating support from institutions for the implementation phase of the project, engaging faculty from other academic disciplines, and providing an opportunity for non-math faculty to share any concerns or insights they may have as the project moves forward.

Background and Context

The Missouri Department of Higher Education (MDHE), in collaboration with the state's institutions of higher education, has for the past several years embarked on a statewide effort to reduce the need for and improve the outcomes of remedial education. As a member of the Complete College America Alliance of States, Missouri has participated in numerous national meetings and academies. In 2013, teams from nine institutions attended the Missouri Completion Academy, which resulted in several institutions adopting strategic plans to reduce remediation and improve learning outcomes; non-participating institutions have taken similar steps. A follow-up to the Completion Academy—to discuss progress and share best practices—was held in 2014. Additionally, legislation enacted in 2012 directed all public institutions of higher education to “replicate best practices in remediation.” Among the many best practices now being implemented is the alignment of gateway courses—particularly those in mathematics—with students’ courses of study.

House Bill 1042

A key to Missouri’s progress in removing barriers to student success has been the passage of key implementing legislation. Missouri participated in the Complete College America completion academy held in Austin, Texas, in 2010. The contingent from Missouri included Sen. David Pearce, Rep. Mike Thomson and the governor’s education policy advisor, Dr. Mike Nietzel. That academy produced exciting results, including several initiatives to improve efficiency (course redesign and performance funding, to name two). It also inspired what came to be known as House Bill 1042, which was adopted in 2012 and led to the creation of the Missouri Reverse Transfer Initiative, the Core Transfer Library, and the adoption of best practices in remediation.

To fulfill the mandate of HB 1042, the MDHE formed the Task Force on College and Career Readiness (TCCR), comprised of chief academic officers and faculty representatives from all sectors of higher education, and later representatives from the K-12 sector (see attachment for roster). Through the work of the TCCR and close collaboration with the public and independent institutions, the MDHE developed Principles of Best Practice in Remedial Education. The Principles is a set of guiding principles and best practices that describe how

remedial education statewide should be structured and delivered, an umbrella of “best practices” under which an institution can devise programs to meet the needs of its particular student body.

Several provisions of the Principles are directly related to the state’s work on math pathways:

1. Statewide Placement Policy

Accurate placement in appropriate coursework is a key to student success. To improve accuracy, institutions must use multiple measures to assess student readiness for gateway courses and programs of study. All institutions will use common scores for the assessment instruments they employ.

2. Gateway Courses

The completion of a set of gateway courses for a course of study is a critical measure of success toward college completion. Remedial education should be designed to help students complete gateway courses in their course of study as quickly as possible.

3. Alternative Pathways

The content in required gateway courses should align with a student’s academic course of study—particularly in math. College Algebra may be an appropriate gateway course for many academic programs, but it should not be the only mathematics pathway for students to earn a postsecondary certificate or degree. Students seeking degrees in non-STEM fields may be served better by other gateway courses such as statistics or geometry.

4. Alternative Delivery

Institutions should explore alternate delivery methods (a.k.a course redesign) to move students into credit bearing courses as quickly as possible and save students time and money. These methods should provide appropriate instruction to accommodate the diversity of their developmental and remedial students.

The institutions are now implementing the Principles of Best Practice in Remedial Education. The TCCR is researching effective measures, and combinations of measures, for use in placing students accurately in entry-level, credit-bearing courses.

The Missouri Mathematics Pathways Task Force

In the spring of 2014, staff from the MDHE began discussions about the state of higher education mathematics in Missouri with various groups, including the Missouri Section of the Mathematical Association of America (MAA), the Missouri Mathematics Association of Two-year Colleges (MOMATYC), and the Missouri Developmental Education Consortium (MoDEC). The primary goal of these discussions was to gather information about and support for the implementation of best practices in remediation, particularly the development of alternative pathways. The MDHE formed a committee to examine the state of mathematics education in Missouri at a statewide summit in the fall of 2014.

The MDHE hosted The Missouri Mathematics Summit: Exploring Alternative Pathways and Course Redesign for Postsecondary Mathematics Education on September 11-12, 2014 in Columbia, Missouri. Missouri institutions of higher education were invited to bring a team of five to seven faculty members and administrators to attend. The purpose of the Summit was to engage faculty and administrators from Missouri's public and independent institutions in a discussion about developing alternative mathematics pathways for students and the course redesign necessary to support these pathways. The summit provided attendees with opportunities to network, discuss current initiatives at their institutions, hear informative presentations, and share best practices in postsecondary mathematics reform. The planning committee developed the program with assistance from the MDHE and financial support from the College and Career Readiness Partnership (a joint partnership of the American Association of State Colleges and Universities, the Council of Chief State School Officers, and the State Higher Education Executive Officers).¹

While planning for the Summit continued, the MDHE was accepted to participate in the "Building Math Pathways into Programs of Study" initiative. To guide the state's work on this initiative, the department formed the Missouri Mathematics Pathways Task Force (MMPT), which was comprised of mathematics department chairs and mathematics educators from nearly every public postsecondary institution. Dr. Mary Shepherd of Northwest Missouri State University agreed to chair the Task Force. Dr. Rusty Monhollon, Assistant Commissioner for Academic Affairs at the MDHE, served as facilitator. Ann Boehmer (East Central College), Kim Granger (St. Louis Community College), and Tammy Randolph (Southeast Missouri State University) were the other three members of the executive committee for the team. The MDHE charged the MMPT to explore options and make recommendations that would increase significantly students' success rates in mathematics gateway courses without compromising the integrity of the mathematics, and increase significantly the percentage of students completing degree programs.

The MMPT held day-long meetings in October and November 2014; and in January, February, March, and May 2015. The MMPT formed four subgroups:

- ▶ Policy Obstacles
- ▶ Alignment Issues
- ▶ Improvement issues, and
- ▶ Math courses and their effect on student success rates and degree completion rates.

Each subgroup was comprised of representatives from both two-year and four-year institutions in Missouri. Each was led by a facilitator and collaborated during MMPT meetings and teleconferences held between Task Force meetings.

¹ The Summit program and Planning Committee Roster is attached in the appendix.

Missouri Mathematics Pathways Task Force Members

Name	Title	Institution
Ian Aberbach	Professor of Mathematics and Director of Undergraduate Studies	University of Missouri-Columbia
Andrew Aberle	Mathematics Instructor	Ozarks Technical Community College
Brihan Barron	Mathematics Faculty	State Technical College of Missouri
Ann Boehmer	Chair of Mathematics and Physical Science Division	East Central College
William O. Bray	Chair of Mathematics Department	Missouri State University
Haiyan Cai	Chair of Mathematics and Computer Science Department	University of Missouri – St. Louis
Jonathan Corbett	Chair of Mathematics and Natural Sciences Department	Harris Stowe-State University
Tabatha Crites	Mathematics Faculty	Mineral Area College
Mark Eriksson	Mathematics Faculty	Three Rivers Community College
David Garth	Professor of Mathematics	Truman State University
Kim Granger	Professor of Mathematics	St. Louis Community College
Jennifer Hegeman	Associate Professor of Mathematics	Missouri Western State University
Cheryl Ingram	Chair of Mathematics and Physical Sciences Division	Crowder College
Kerry Johnson	Chair of Mathematics Department	Missouri Southern State University
Bill Kalahurka	Assistant Teaching Professor of Mathematics	University of Missouri – Kansas City
Donna Kessler	Mathematics Instructor	Moberly Area Community College
Wanda Long	Professor of Mathematics	St. Charles Community College
Phoebe McLaughlin	Professor of Statistics and Mathematics	University of Central Missouri
Kimberly Miller	Chair of Mathematics Division	State Fair Community College
Rusty Monhollow	Assistant Commissioner of Academic Affairs	Missouri Department of Higher Education
Bill Morgan	Mathematics Faculty	Metropolitan Community College
Jennifer Plemons	Research Associate	Missouri Department of Higher Education
Tammy Randolph	Department of Mathematics Chair	Southeast Missouri State University
Skyler Ross	Associate Professor of Mathematics	Jefferson College
V.A. Samaranayake	Curator's Teaching Professor of Mathematics & Statistics, and Director of Graduate Studies	Missouri University of Science and Technology
Mary Shepherd	Professor of Mathematics	Northwest Missouri State University
Ruthi Sturdevant	Professor of Mathematics	Lincoln University
Tracy Welch	Mathematics Faculty	North Central Missouri College
Alternate Members		
Stephanie Fitch	Associate Teaching Professor of Mathematics	Missouri University of Science and Technology
Trish White	Developmental Mathematics Instructor	Ozarks Technical Community College

I. Removing Policy Obstacles

Higher education has evolved over the past century. With it, undergraduate general education mathematics course requirements have undergone significant change. In the early 1900s, the entry-level mathematics course that liberal arts students took included Calculus topics.² Additionally, not all students were required to take a mathematics course to fulfill the general education requirements for a liberal arts degree. For example, in 1928, the entry level mathematics course at Washington University College of Liberal Arts in St. Louis included the topics in algebra, trigonometry, and elementary notions on analytic geometry and calculus. The prerequisite for the course was high school algebra and geometry. Most degrees did not require a mathematics course, but instead required students to select one course from a list of courses from selected disciplines. A pre-commerce student was required to select a course in either science or mathematics their freshman year, and then another course in science, mathematics or psychology their sophomore year. A nursing student, pre-legal student or other student working towards a Bachelor of Arts degree needed only to select one course in either mathematics, Latin, or Greek.³

To keep up with changes in society and our educational system, educators need to be willing to make changes to national, state and institutional policies. Currently in Missouri, most students fulfill the general education mathematics requirement by taking College Algebra. Even though College Algebra was created to prepare students for Calculus, most students who take College Algebra do not intend to take Calculus. Furthermore, Intermediate Algebra was created to prepare students for College Algebra, yet Intermediate Algebra is used as a prerequisite for all entry-level courses that are used to meet the general education mathematics requirement of their degree program regardless of the mismatch of the course objectives and learning outcomes.⁴

² Alan Tucker, The History of the Undergraduate Program in Mathematics in the United States. *The American Mathematical Monthly* 120.8 (2013): 689–705.

³ Washington University St. Louis. Catalogue of the College of Liberal Arts, February 20, 1928.

⁴ Tucker, Alan. The History of the Undergraduate Program in Mathematics in the United States. *The American Mathematical Monthly* 120.8 (2013): 689–705.2012.

Issue 1.1: CBHE Policies

The Missouri Coordinating Board for Higher Education (CBHE) has a policy that states “The mathematics requirement for general education should have the same prerequisite(s) and level of rigor as College Algebra.”⁵ Intermediate Algebra is currently the prerequisite course for College Algebra in most Missouri colleges and universities. Students can place directly into College Algebra if they are able to demonstrate that they already have the knowledge and skills deemed necessary to be successful in College Algebra. Thus, according to this CBHE policy, any course that is developed as an alternative course to College Algebra must also have the prerequisite of Intermediate Algebra.

The topics covered in Intermediate Algebra are the topics that a student needs to know and understand in order to be successful in College Algebra. If other courses are to be developed as alternatives to College Algebra, then the prerequisites for such courses should be courses which cover topics that a student needs to know and understand in order to be successful in those alternative courses. The list of knowledge and skills that a student needs in order to be successful in a Statistics or Quantitative Reasoning course will have many—but not all—of competencies and skills a student needs to be successful in a College Algebra course.

In November 2014, the American Mathematical Association of Two-year Colleges (AMATYC) passed a position statement regarding the appropriate use of Intermediate Algebra as a prerequisite course. AMATYC’s position is that the prerequisite of any mathematics course should be a course that prepares a student to succeed in that course for which it is a prerequisite.⁶ AMATYC’s position stands contrary to the current CBHE policy.

- Recommendation 1.1: Revise the CBHE policy regarding prerequisite courses for entry-level general education mathematics courses so that the prerequisite course for each college-level course is appropriate for each individual course. The MDHE should form a workgroup to revise the policy. This group should be comprised of

⁵ Missouri Coordinating Board for Higher Education, *Principles of Best Practices in Developmental Education*, 2012.

⁶ American Mathematical Association of Two-year Colleges. (2014, November). Position Statement on The Appropriate Use of Intermediate Algebra as a Prerequisite. Retrieved from www.amatyc.org/?page=PositionInterAlg

mathematics and statistics faculty from around the state who represent the mathematics and statistics departments in their respective institutions.

This policy change is critical to the work towards providing students with alternative pathways to and through the general education mathematics requirements.

Issue 1.2: Alternative Mathematics Pathways

Most colleges and universities in Missouri have created rigorous, college-level courses that serve as an alternative to College Algebra. As well, most Missouri universities allow students to meet the general education mathematics requirement for a bachelor's degree in non-STEM fields by taking a mathematics course other than College Algebra, such as mathematical, quantitative, or statistical reasoning course.⁷ These courses were intended to provide students with a course that meets the general education requirements for mathematics while being relevant to their pathway of study. For example, students who intend to major in art, history or English can take a quantitative reasoning mathematics course designed for liberal arts students. Although these courses are being offered to students in Missouri, the enrollment in such courses is not proportionate to the number of students intending to major in non-STEM disciplines. Rather than take a general education mathematics course that is relevant to a student's major, most Missouri students still take College Algebra. Many students fail College Algebra several times before making it past this barrier to their degree completion; some give up without completing their degree.

One reason that community college students or university students who believe that they might transfer to another university take College Algebra is because they are confident that College Algebra will transfer to other Missouri colleges and universities for all majors. Registration advisors often advise students to take College Algebra for this reason. As a result, there needs to be articulation agreements for the alternative pathway mathematics courses to meet the general education mathematics requirements in Missouri.

⁷ These kind of courses currently exist in Missouri and go by different names, such as Contemporary Mathematics and General Statistics.

Until students are confident that the alternative mathematics course will transfer and meet the degree requirements of the institution they transfer to, students will continue to enroll in College Algebra fearing that the alternative mathematics course will not transfer. In short, it is not sufficient to create alternative pathway mathematics courses. The creation of such courses will have little effect on degree completion rates until students have the confidence to enroll in the courses, and strong state-wide articulation agreements will give students the assurance that the courses will in fact transfer and fulfill their degree requirements.

- ▶ Recommendation 1.2: Establish statewide articulation agreements (while respecting the autonomy of each institution to establish its own general education and graduation requirements within the context of Missouri statutes) for the alternative pathway mathematics courses that meet the general education mathematics requirements and their prerequisite courses. The goal is to create pathways to provide students with the mathematics skills and knowledge they need to be successful in their program of study, such as a college-level quantitative reasoning course and a college-level statistics course. In addition, appropriate prerequisite courses, such as mathematics literacy, should also be developed.

Missouri colleges and universities should establish articulation agreements for these courses so that the courses will transfer easily. The MDHE should form a workgroup to develop this articulation agreement. Additionally, courses that are developed to offer students alternative mathematics pathways should be included in the transfer library, as required by HB 1042.

II. Aligning secondary and postsecondary mathematics content and instruction

Higher education institutions are situated to better serve students when they have clear communication and alignment with the K-12 school systems. Stake holders that benefit from this alignment include students, parents, teachers and tax payers. When the K-12 and the higher education systems are not aligned, students and teachers lose valuable time, and parents and tax payers pay for redundant courses. Everyone involved will benefit from increasing the number of high school graduates in Missouri who test into and pass on the first attempt college-level courses at the point of entering college.

To ensure that more students are able to start their college career without retaking high school subjects and to ensure that students who test into a college-level mathematics course right out of high school pass the course the first time around, high school courses and the new Pathway courses need to be aligned; responsibility for this alignment falls to both K-12 and higher education. Additionally, there is a need for clear communication between high schools and colleges regarding expectations at the college level, the appropriate courses for college-bound students, and the lapse of time between courses.

Issue 2.1: Placement into Alternative Mathematics Pathways

The benchmark score for college readiness on the mathematics section of the ACT test is 22, which means a student who earns a 22 on the ACT math subscore has a 50 percent chance of obtaining a B or higher and a 75 percent chance of obtaining a C or higher in the corresponding credit-bearing college course. According to the ACT, only 45 percent of the Missouri 2014 high school graduates who took the ACT met the college readiness benchmark for College Algebra.⁸ However, the ACT does not provide a benchmark score that can be used to place students into other entry-level college mathematics courses. Missouri institutions are required to use multiple measures to determine a student's placement in credit-bearing of remedial course. Most assessment instruments—such as the Compass or Accuplacer—may not be reliable in assessing a student's readiness for a college-level course other than College Algebra.

It is clear that if alternative pathways in college level mathematics are to be created in Missouri, the placement into these mathematics courses must be reevaluated.

- Recommendation 2.1: Institutions should align the process of placing students in credit-bearing courses with alternative pathway courses. Multiple measures should be used to assess student placement, and it should not be assumed that the same measures are appropriate for all college-level mathematics courses.

In an effort to increase student success rates and decrease a student's time to graduation, the placement process should include instruments that measure competencies required for courses within the pathway. The instrument should be based on data and should not necessarily be the same for all courses, in the same way that it would be absurd to use one language placement test to place students accurately in French, German or Spanish courses. The instrument should capture the diversity of student backgrounds relating to the number of years of high school math, the elapsed time since their last math class, and test scores. Multiple measures should be used to place students into the various college-level mathematics courses.

Issue 2.2: K-12 and Higher Education Alignment

As noted above, not all students who graduate from Missouri high schools are prepared for College Algebra. It is possible that as new courses are developed to meet the general education mathematics requirements, some high school graduates might not be prepared for those courses either. It is imperative that the content of the new college-level mathematics courses align with the content of high school mathematics courses so that college-bound high school students are able to test into and pass entry-level college mathematics courses. Some high school graduates are underprepared for college-level mathematics because they have not taken the right mathematics courses in high school or because they have not taken mathematics courses the last year or even two years of high school.⁹

- Recommendation 2.2: The K-12 and higher education sectors should collaborate to align high school mathematics courses with entry college-level mathematics courses. The higher education sector must clearly communicate college-level expectations to high schools so as to provide a smooth transition from the K-12 system to the higher education system. The State Board of Education should adopt the CBHE Recommended College Preparatory High School Curriculum.

⁸ ACT, Missouri State Profile for the Graduating Class of 2014. Retrieved from <http://www.act.org/newsroom/data/2014/pdf/profile/Missouri.pdf>

⁹ Research confirms that students who have taken four or more mathematics courses in high school have greater success in college-level mathematics courses. The research also suggests the importance of taking a mathematics course in the senior year of high school. The CBHE Recommended College Preparatory High School Curriculum was updated in 2012 to reflect this research; it is available <http://dhe.mo.gov/policies/hs-core.php>

In an effort to increase student success rates and decrease a student's time to graduation, the CBHE should communicate with K-12 systems about the new courses and their prerequisite skills so as to align each new course created within pathways to the mathematics content taught in Missouri high schools. Students who take and pass the mathematics courses prescribed by the Missouri Department of Higher Education for college-bound students should be able to place into college-level mathematics courses when they go to college. High school mathematics courses should, in essence, meet the same learning objectives as the prerequisite courses offered by colleges. In addition, colleges and universities need to communicate more clearly and openly with high school counselors who advise students about their course selection in high school.

Issue 2.3: Aligning Mathematics Courses with Programs of Study

College-level courses that meet the general education mathematics requirements should align with programs of study. The College Algebra course was created to prepare students for Calculus. Students who are not intending to take Calculus should have the option of taking a college-level mathematics course that relates more closely to their program of study.

- ▶ Recommendation 2.3: Create college-level mathematics courses that serve as alternatives to the College Algebra course and that are aligned to targeted programs of study. The MDHE should appoint a workgroup consisting of mathematicians, statisticians, and other faculty to develop these alternative courses.

Some colleges and universities around the nation, including many in Missouri, offer courses in mathematical, quantitative, or statistical reasoning to fulfill mathematics general education requirements. Unlike College Algebra, which is accepted in transfer as an equivalent at all public institutions, we do not know the extent to which such courses offered by Missouri colleges and universities have similar learning objectives and outcomes. Therefore, the MDHE should create a statewide workgroup of mathematics and statistics faculty to identify the suggested outcomes and objectives for entry-level, college-level alternative mathematics courses that fulfill general education requirements. The course objectives should be based on the current research and best practices around alternative courses being offered around the country,

rather than simply merging course objectives from the various existing courses. The work of the Dana Center, Carnegie Center and AMATYC's New Life Mathematics project all should be consulted as these courses are being developed. Furthermore, this list of student learning outcomes might be useful in determining articulation of the courses among institutions.

Issue 2.4: Alternative Mathematics Course Prerequisites
The purpose of prerequisites is to provide the student with the skills and knowledge needed to be successful in the subsequent course. The prerequisites for entry-level, college-level alternative mathematics courses that fulfill general education requirements will not necessarily be the same for all courses. Thus, each general education mathematics course should have appropriate prerequisites.

- ▶ Recommendation 2.4: Identify prerequisites for alternative college-level mathematics courses that are aligned to targeted programs of study. The learning objectives and outcomes for these prerequisites should match the skills and knowledge needed by a student to be successful in subsequent courses and should have some statewide consistency. The MDHE should appoint a workgroup consisting of mathematicians, statisticians, and other faculty to develop these prerequisites.

The prerequisites should be created using a backward design approach, with the course learning objectives driving the decision regarding what topics to include. The prerequisites should be crafted by mathematics faculty to specifically meet the needs of a student who is preparing to take an appropriate college-level mathematics course. The Dana Center, the Carnegie Foundation, and AMATYC's New Life Math Program have created such courses, and their work and research of these reputable groups should be consulted when Missouri embarks on this work.

III. Collecting, analyzing and sharing data

Institutions of higher education often make changes with the goals of increasing student success, improving learning, and raising graduation rates. As Missouri colleges and universities work to improve college completion through the development of pathways to and through the general education mathematics courses, it is critical that comparable data be collected, analyzed, and shared across the state so that we know which changes have increased student success.

Issue 3.1: Institutional Faculty and Staff Engagement

Every public two-year and four-year institution in Missouri has either a faculty member or administrator serving on the MMPT as a representative of that institution. Though MMPT members have kept members of their institutions informed about the work of the MMPT, it will be beneficial to bring teams from each institution together to ensure that the work of the MMPT is being fully shared with all institutions.

- ▶ Recommendation 3.1: The MDHE should hold a second Mathematics Summit to disseminate information and policy recommendations regarding the work of the MMPT, to encourage the creation of new mathematics pathway courses and to present data collected by institutions that have embarked on this effort.

In fall 2014, the MDHE hosted the Missouri Mathematics Summit, the purpose of which was to bring together faculty and administrators from around the state to explore alternative pathways and course redesign for postsecondary mathematics education. The second Missouri Mathematics Summit will provide Missouri institutions with an update of the work done by the MMPT and disseminate further the policy recommendations of the MMPT. Teams of faculty members and administrators should be invited from all two- and four-year public and private institutions. The Summit presenters should include faculty who have experienced program success and failure in pathway courses as early adopters.

Issue 3.2: Data Collection and Evaluation

When new course placement requirements are put in place, it can be difficult to ascertain whether the new requirements are appropriate. After placement guidelines have been instituted for new pathways courses, the procedure should be evaluated to determine whether any revisions need to be made for improvement.

Missouri higher education institutions should report grade data so that the level of success in developmental courses, gateway courses and courses which require gateway courses can be examined.

- ▶ Recommendation 3.2: The MDHE, in consultation with the institutions of higher education, should develop a process for the collection and analysis of data regarding the success of alternative courses, including but not limited to success rates in developmental and gateway courses, and courses that require gateway courses. Further, the MDHE should collaborate with the institutions in analyzing the data to make recommendations regarding the effectiveness of math placement strategies.

At the time new placement guidelines are established, a date for evaluating the effectiveness of the placement procedures should be set. Data should be collected and analyzed to refine the placement guidelines. Procedures should be put in place in advance for the facilitation of accurate, easy, statewide collection of consistent data. This data should be analyzed to determine if the work done to create alternative math pathways has improved student success and degree completion rates.

Conclusion

Over the past eight months, the Missouri Mathematics Pathways Task Force has worked diligently to identify strategies to achieve the objectives of HB 1042 and the "Building Math Pathways into Programs of Study" initiative. This report will be shared with other stakeholders, including the Coordinating Board for Higher Education, the CBHE Presidential Advisory Committee, the Missouri Chapter of the Mathematical Association of America, the Missouri Mathematics Association of Two-Year Colleges, the Missouri Developmental Education Consortium, and the Council of Chief Academic Officers.

As the project moves into its second year, the MMPT is prepared to implement the recommendations contained in this report. This work will include:

- ▶ Developing strategies to familiarize departments, instructors, and advisors with alternative approaches to entry-level courses, inclusive of content, instruction, and delivery mechanisms.
- ▶ Communicating information among chairpersons about best practices and about ways to move promising efforts to scale.
- ▶ Communicating the task force's recommendations to relevant professional associations, state decision-makers, university and college leaders, and other relevant stakeholders.

- ▶ Collecting and analyzing data to measure effectiveness of existing and new entry-level mathematics courses, including dual enrollment courses taught in the high schools. Establish calendars for monitoring student success over time and for the periodic review of policies and practices.
- ▶ Exploring ways to improve alignment with K-12, specifically to ensure that college-level and developmental-level mathematics courses reflect the secondary-level CCSSM and to ensure that dual enrollment courses in any setting are equivalent to taking the course on a college campus.

We intend to launch the implementation phase at the Missouri's second mathematics summit to be held in September 2015 in Columbia, Missouri. This summit will be geared towards generating support from institutions for the implementation phase of the project, engaging faculty from other academic disciplines, and providing an opportunity for non-math faculty to share any concerns or insights they may have as the project moves forward.

Appendix



Missouri Mathematics Summit

*Exploring alternative pathways and course redesign
for postsecondary mathematics education*

Hilton Garden Inn • 3300 Vandiver Drive • Columbia, MO 65202

Summit Program

Thursday, September 11

6:30 p.m.	Optional Reception
7:00 p.m.	Welcome and Purpose for Mathematics Summit

Friday, September 12

7:30 a.m. – 8:30 a.m.	Registration and Continental Breakfast
8:30 a.m. – 8:45 a.m.	Welcome <i>Dr. Rusty Monhollon, Assistant Commissioner for Academic Affairs, Missouri Department of Higher Education</i>
8:45 a.m. – 10:00 a.m.	Plenary Session I: Applications of the Predictive Capability of Early-Semester Data in Gateway Math Courses <i>Dr. Greg Budzban, Chair, Department of Mathematics, Southern Illinois University-Carbondale</i>
10:00 a.m. – 10:15 a.m.	Break
10:15 a.m. – 11:30 a.m.	Plenary Session II: Math Literacy: A Non-STEM Pathway to College Readiness <i>Kathleen Almy, Professor of Mathematics, Rock Valley College, Rockford, IL</i>
11:30 p.m. – 1:00 p.m.	Lunch Presentation: Alternative Pathways at Austin Peay State University <i>Dr. Loretta Ussery Griffy, Director of the Center for Teaching and Learning, Austin Peay State University, Clarksville, Tennessee</i>
1:00 p.m. – 2:30 p.m.	Breakout Sessions 1. Generating faculty interest and faculty-driven mathematics reform <i>Dr. Greg Budzban, Dr. Tammy Randolph</i> 2. Building statewide support for mathematics reform <i>Dr. Loretta Ussery Griffy</i> 3. Improving student success using online methods of math instruction <i>Dr. Kimberlyann Tsai Granger</i> 4. Next Steps: Implementing a math literacy course <i>Kathleen Almy</i>
2:30 p.m. – 2:45 p.m.	Break
2:45 p.m. – 3:45 p.m.	Panel Discussion <i>Kathleen Almy, Greg Budzban, Loretta Griffy, Bruce Vandal</i>
3:45 p.m. – 4:00 p.m.	Next Steps and Closing Remarks <i>Rusty Monhollon</i>

TCCR Math Summit Planning Committee Roster

Name	Title	Institution
Charlene Atkins	Professor	University of Central Missouri
Ann Boehmer	Chair of Mathematics and Physical Science Division	East Central College
Jeff Cawlfield	Vice Provost for Undergraduate Studies	Missouri University of Science & Technology
Kim Granger	Professor of Mathematics	St. Louis Community College
Paul Long	Vice Chancellor of Academic Affairs and Technology	Metropolitan Community College
Wanda Long	Professor of Mathematics	St. Charles Community College
Ann McCoy	Professor - President - MAT^2	University of Central Missouri
Rusty Monhollon	Assistant Commissioner of Academic Affairs	Missouri Department of Higher Education
Jennifer Plemons	Research Associate	Missouri Department of Higher Education
Mary Shepherd	Professor of Mathematics	Northwest Missouri State University